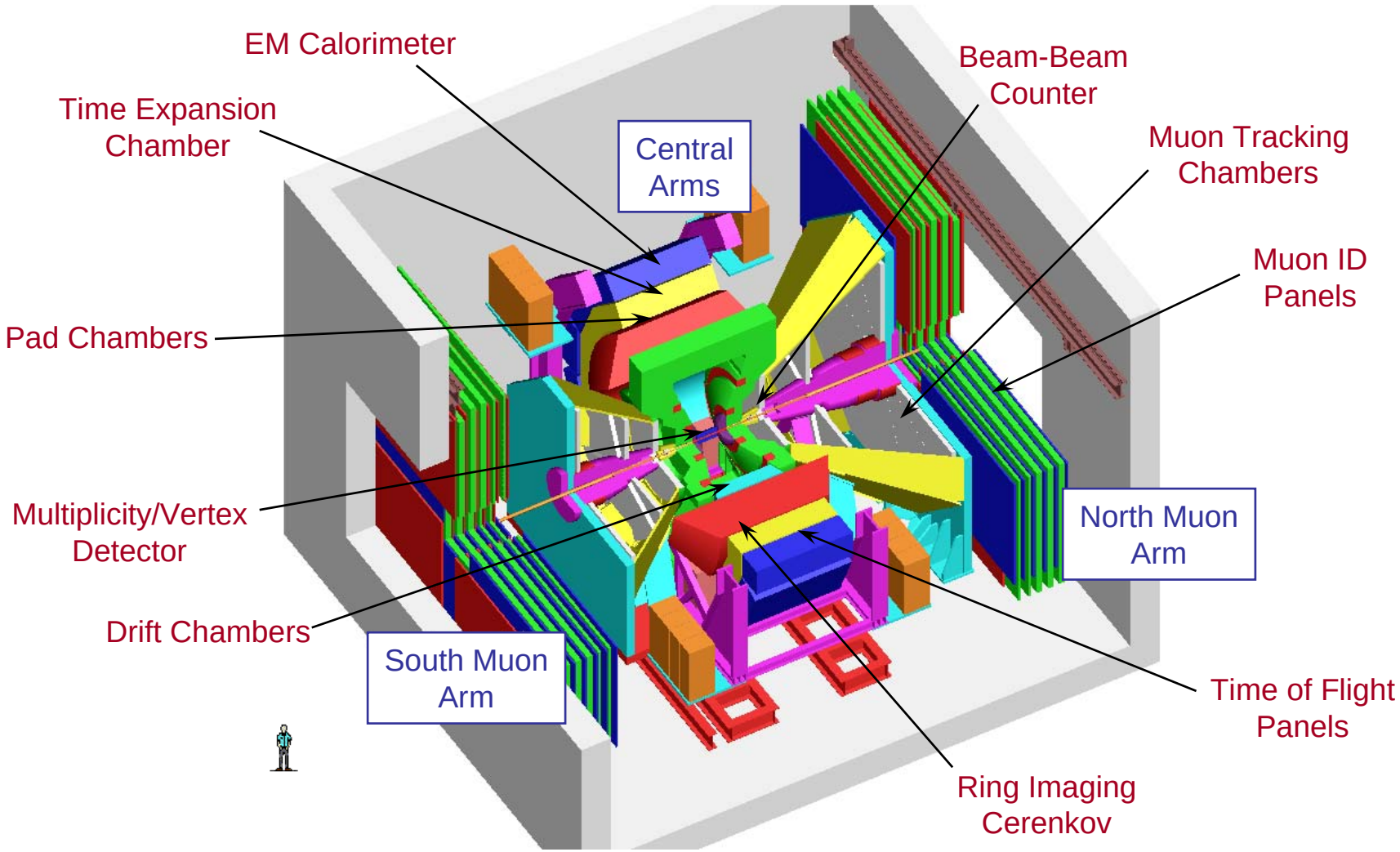
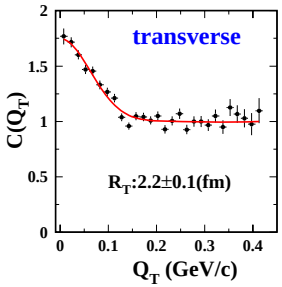
Run-5, PHENIX and You

- Brief Overview – PHENIX in Run-5
  - Physics and Detector Setup
  - PHENIX Goals and Performance
    - CuCu @200, 62.4 and 22.4 GeV/c
    - Polarized pp @200, 410 GeV
- From Delivered To Sampled Luminosity
  - The PHENIX duty cycle
    - What can we learn from Run-5?
    - Shift training issues
  - The PHENIX vertex cut
- The Machine/Experiment Interface
  - Projections and Performance for future runs
  - Day-to-day operational issues
- PHENIX, Run-6 and Beyond
  - Planned upgrades
  - Luminosity and backgrounds

The PHENIX Detector



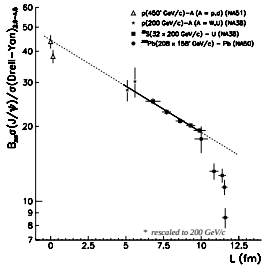
NA44



single particle distributions

semi-leptonic D decays

NA50

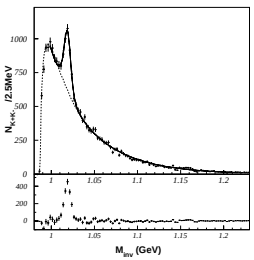


strangeness production

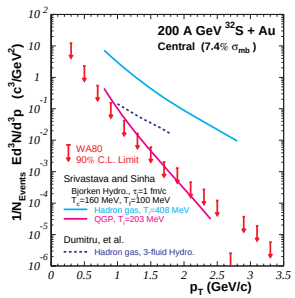
heavy flavor decay

spin program W^+,W^-

E859



WA80



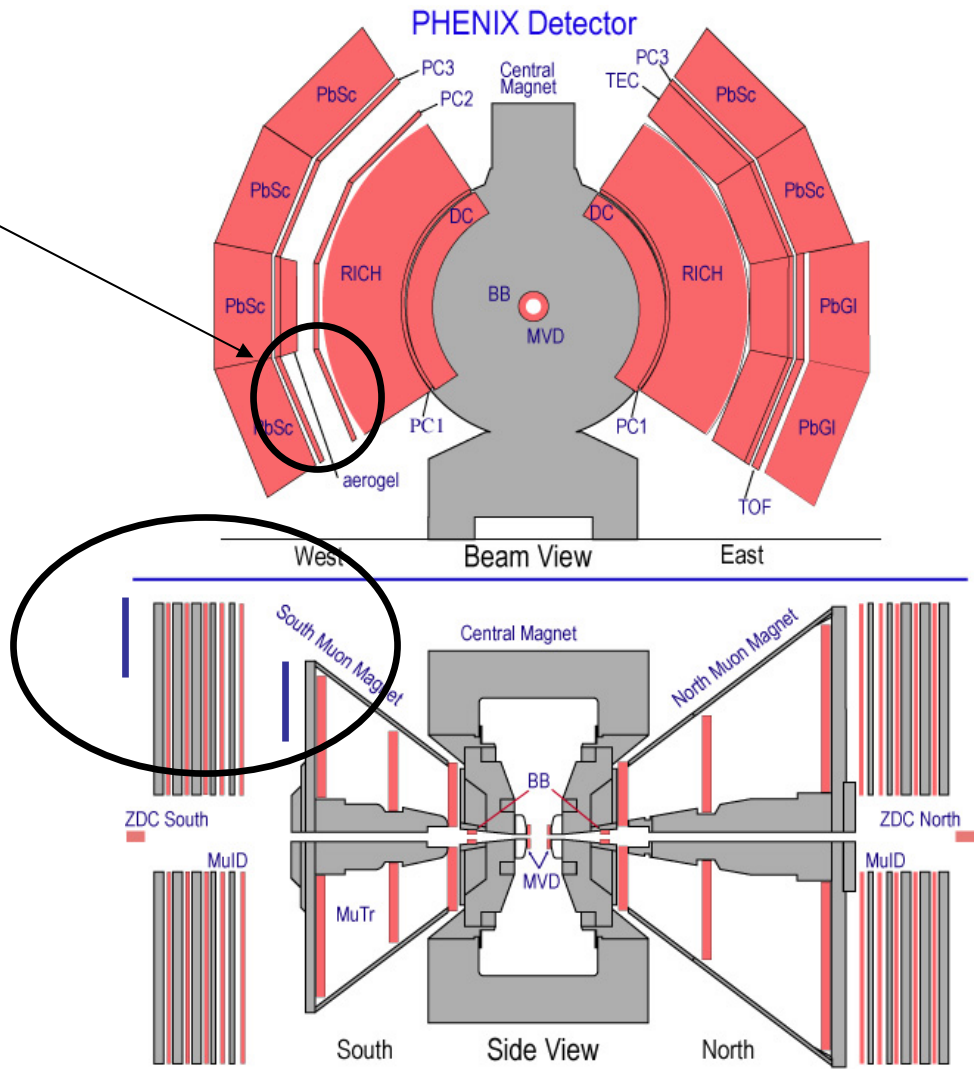
E_T, $dE_T/d\eta$, fluctuations

jet quenching

PHENIX in Run-5

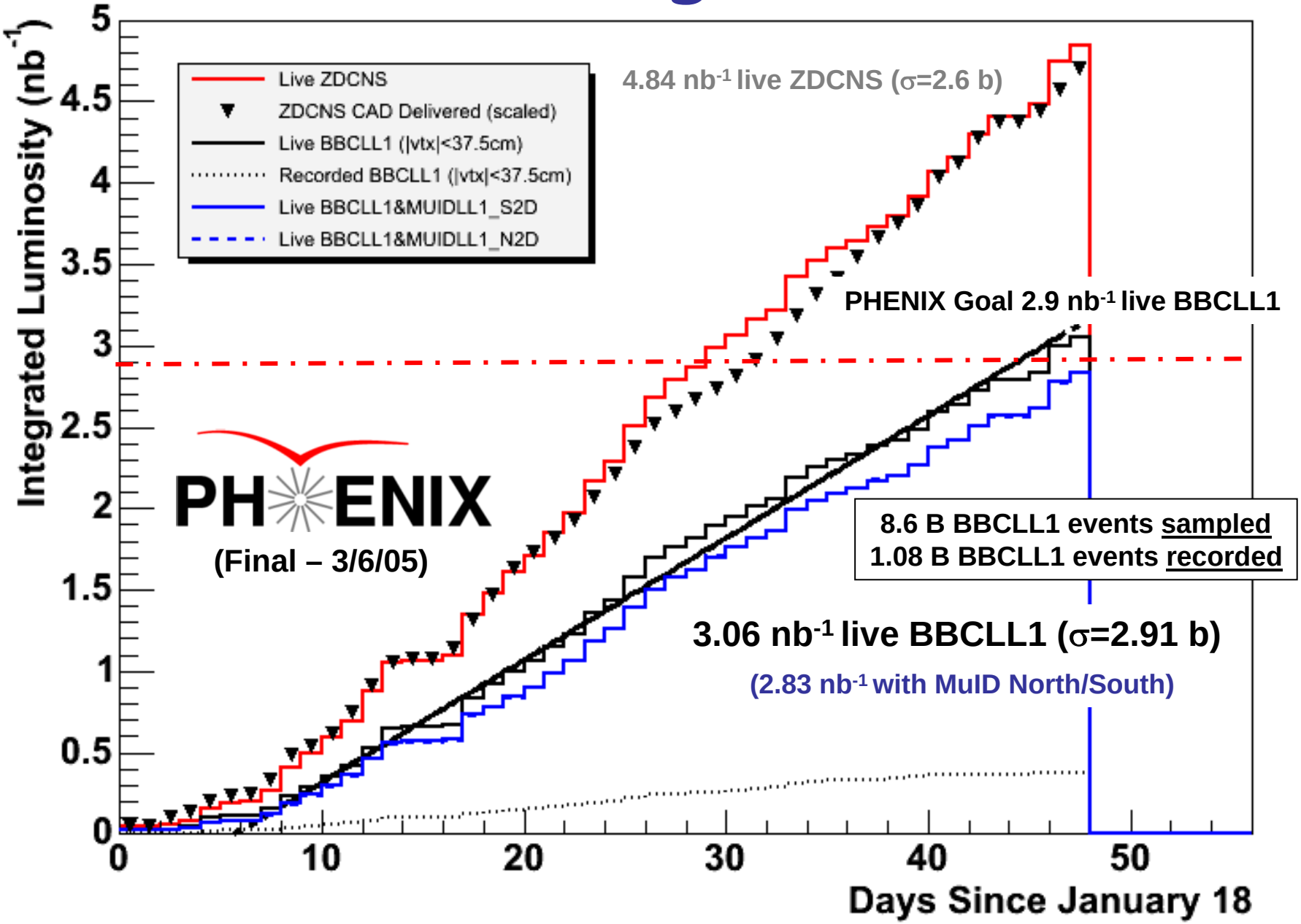
TOF-West RPC prototype installed and tested in CuCu running.

Prototype RPC muon trigger chambers installed for pp running.



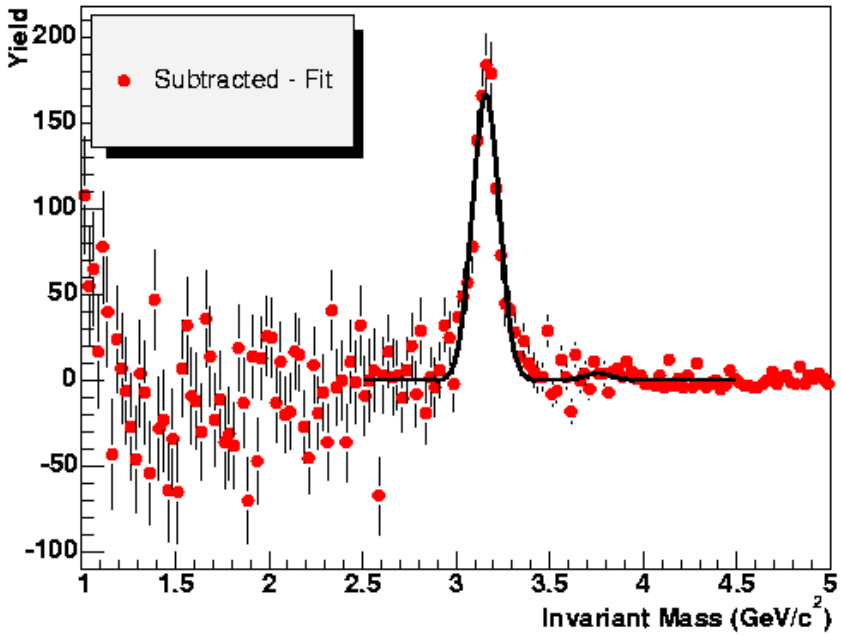
ALSO:
Improved DAQ (>5kHz)
Multi-Event Buffering (95% live)
New LVL1 Triggers
OnCal calibrations
LVL2 Filtering rare events
CC-J Data Transfers @50MB/s

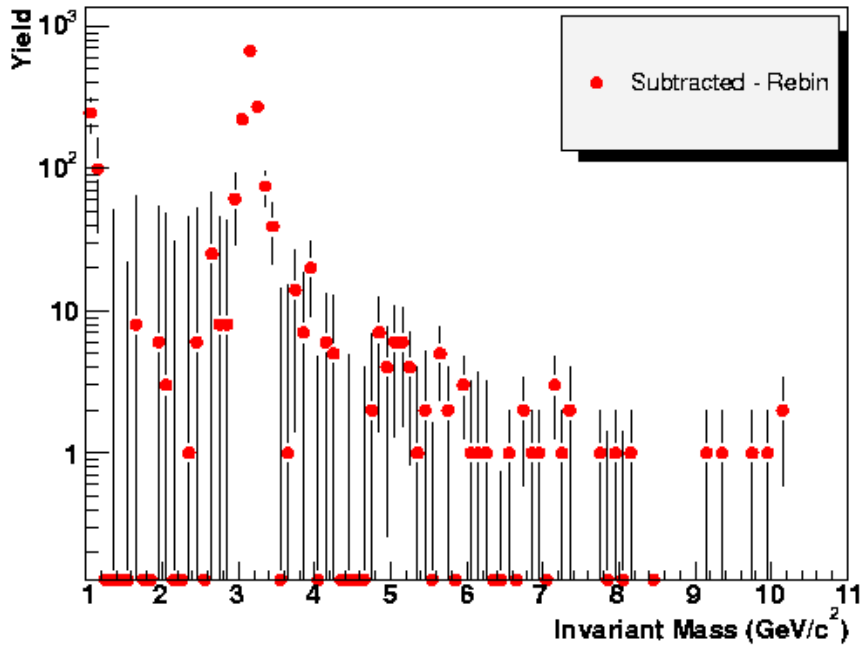
200GeV CuCu Integrated Luminosity



J/Ψ→e⁺e⁻ in CuCu 200 GeV

- J/Ψ in central arm data:





1249+/-61 J/Ψ

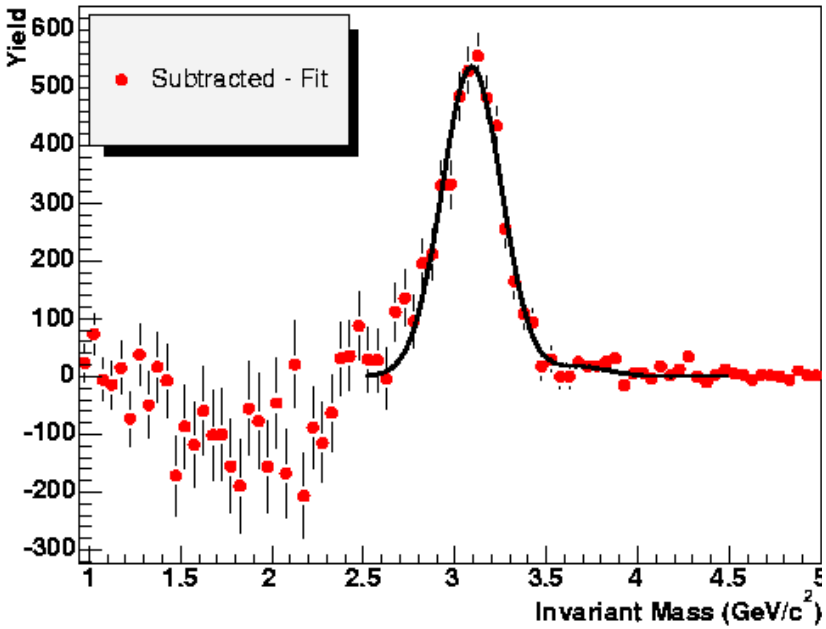
32+/-20 Ψ' (3%)

Handful of counts in upsilon mass region

J/Ψ→$\mu^+\mu^-$ in CuCu 200 GeV

- J/Ψ in LVL2 filtered events:

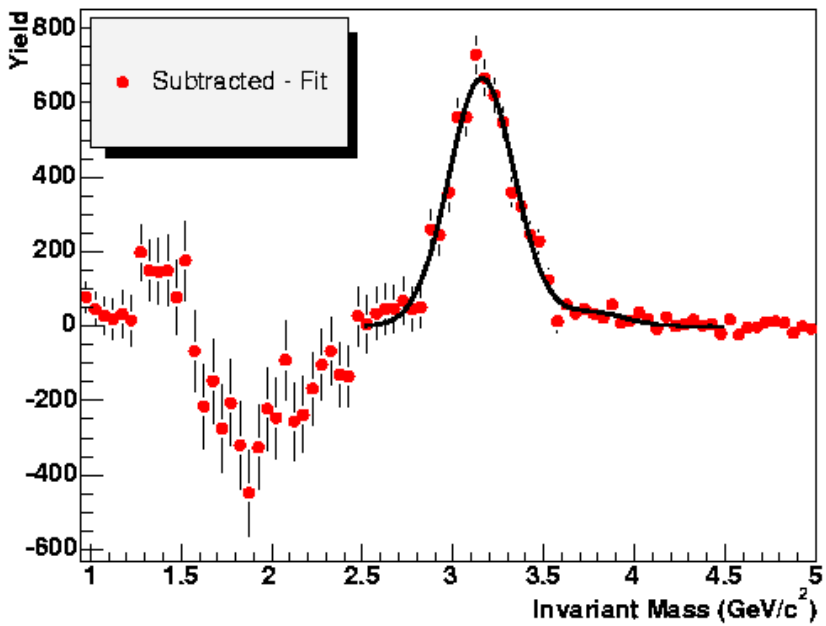
North Muon Arm



4690+/-162 J/Ψ,

201+/-65 Ψ' (4%)

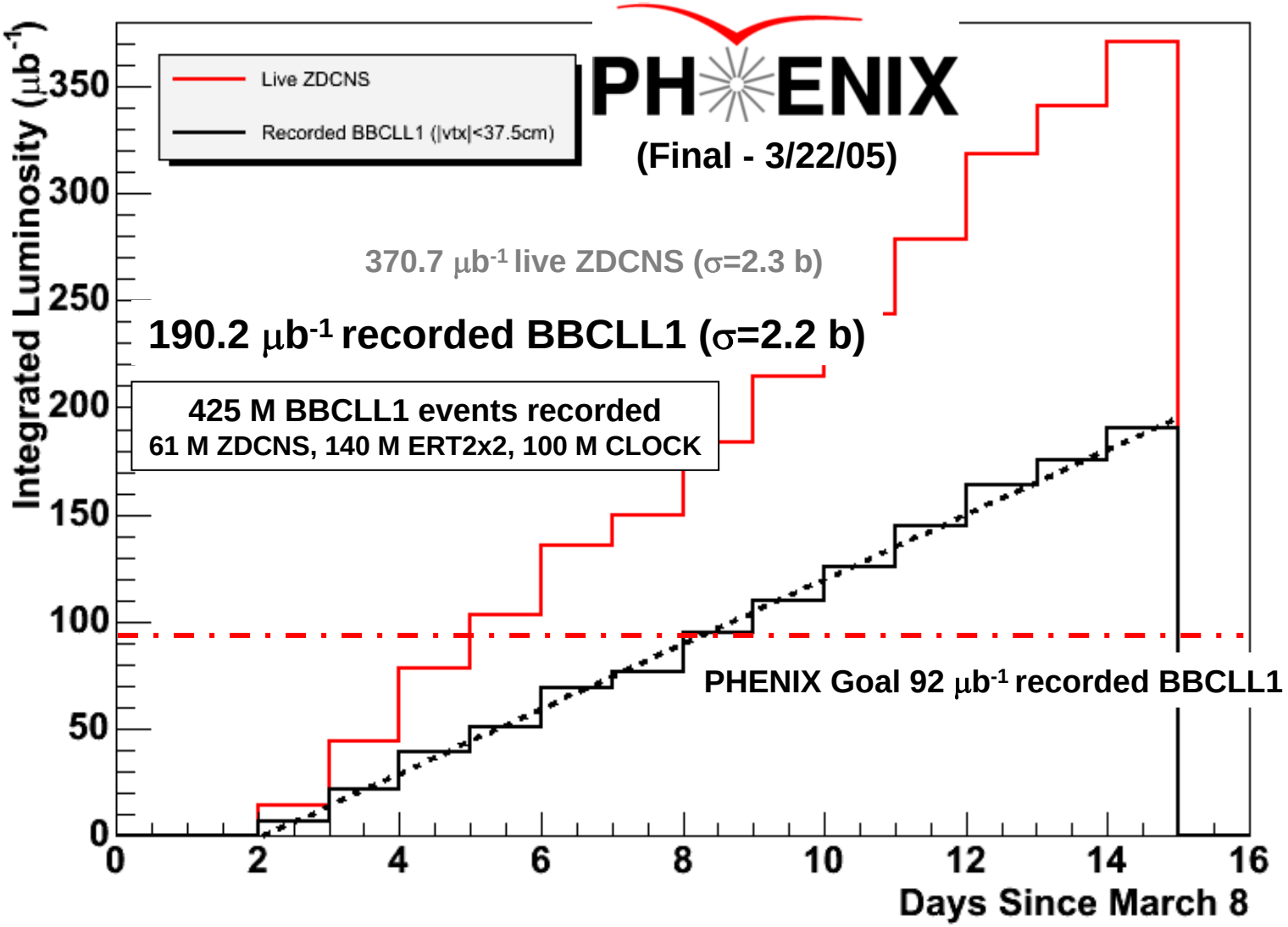
South Muon Arm



6567+/-201 J/Ψ,

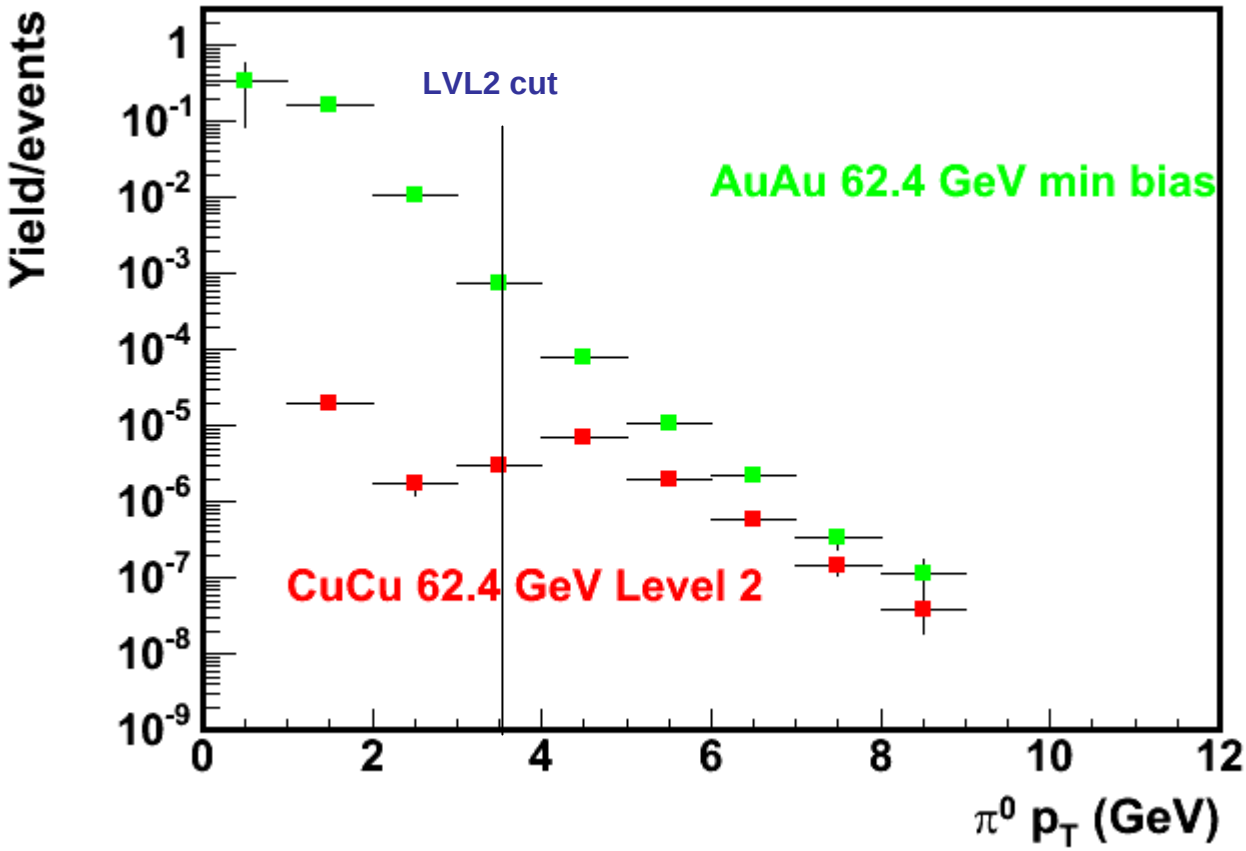
357+/-82 Ψ' (5%)

62.4 GeV CuCu Integrated Luminosity



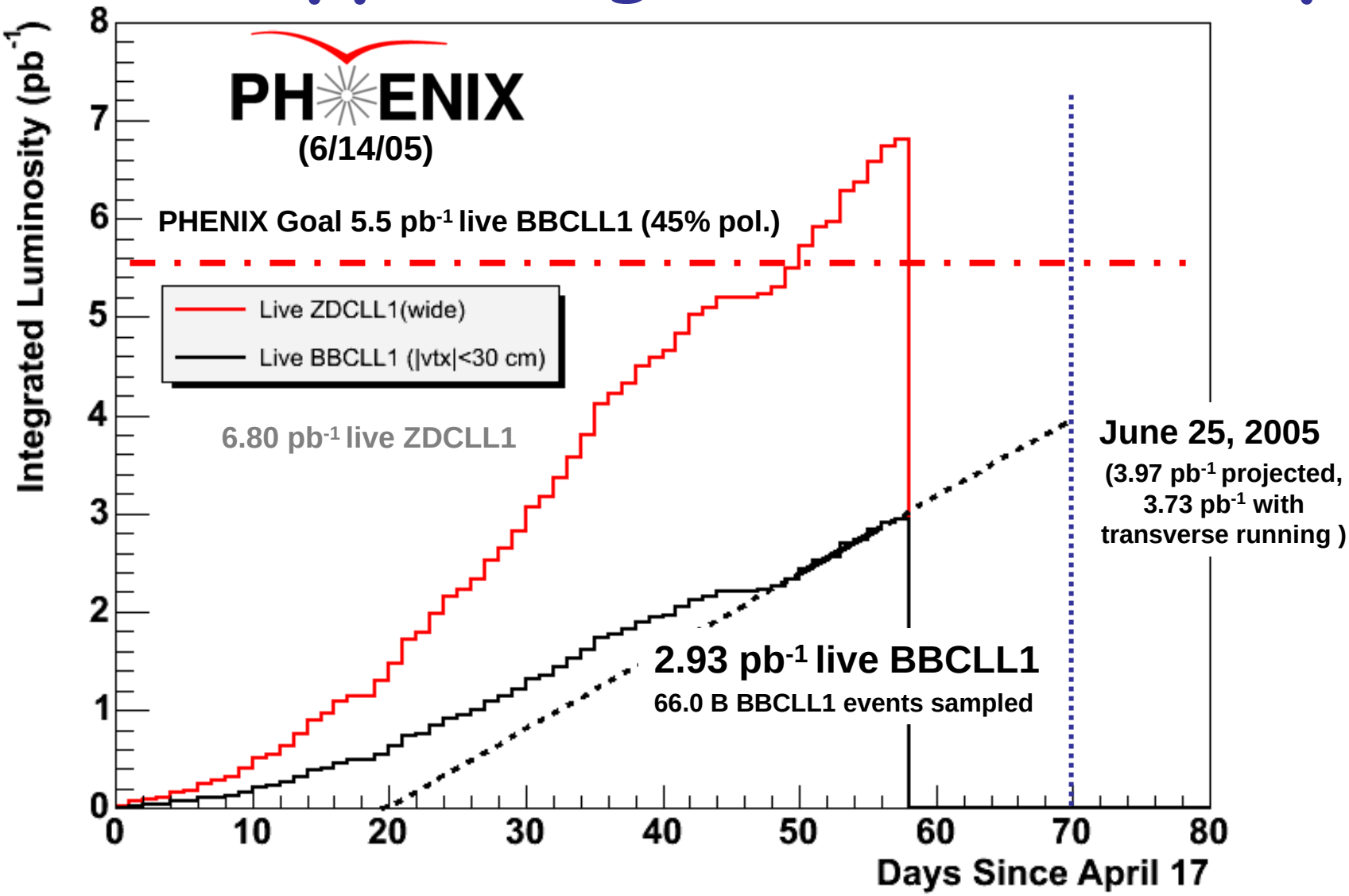
π^0 Reach in CuCu 62.4 GeV

- Goal was p_T reach comparable to AuAu 62.4 GeV

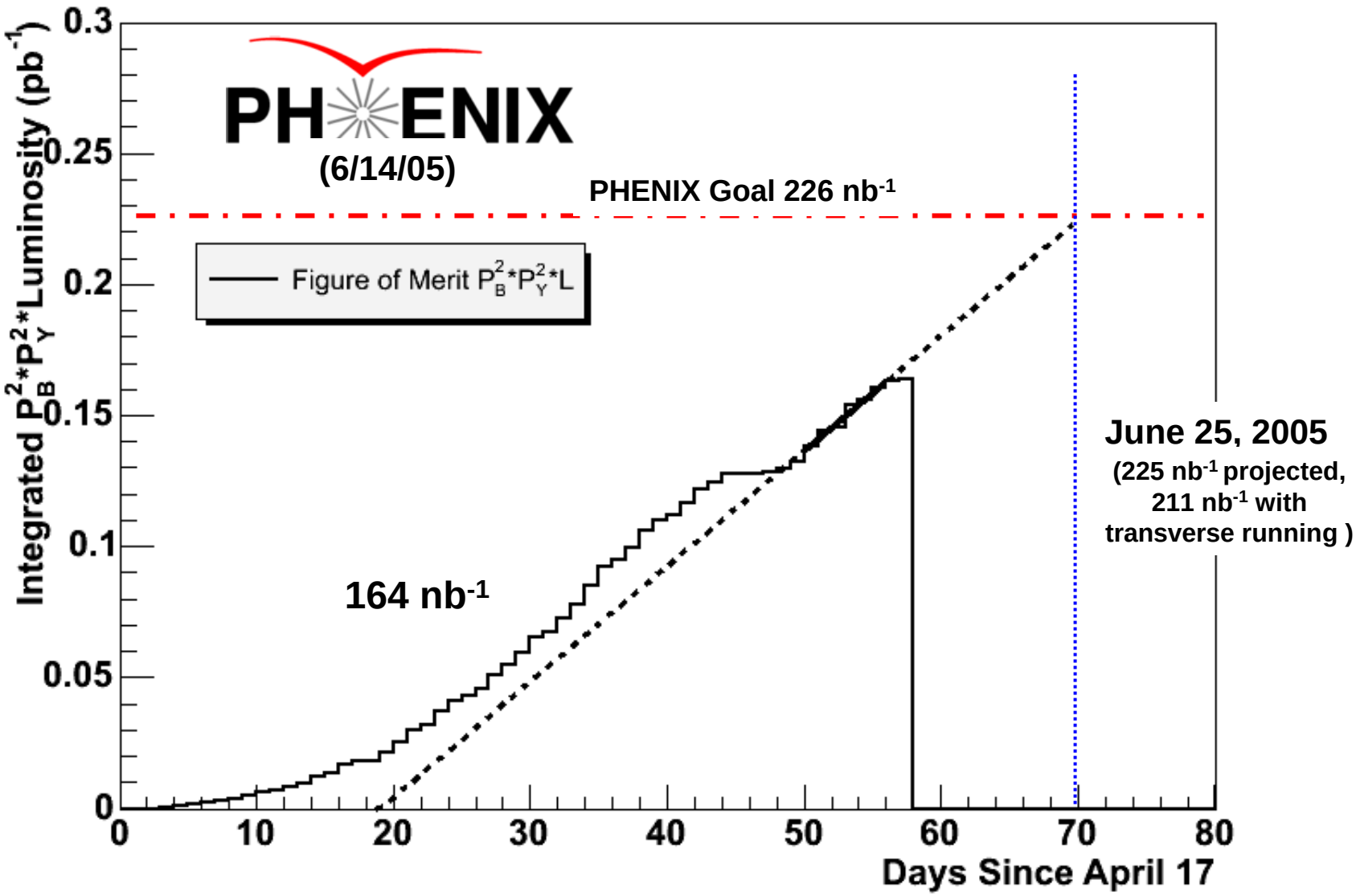


Filtered LVL2 on 161M minbias events (39% of total).

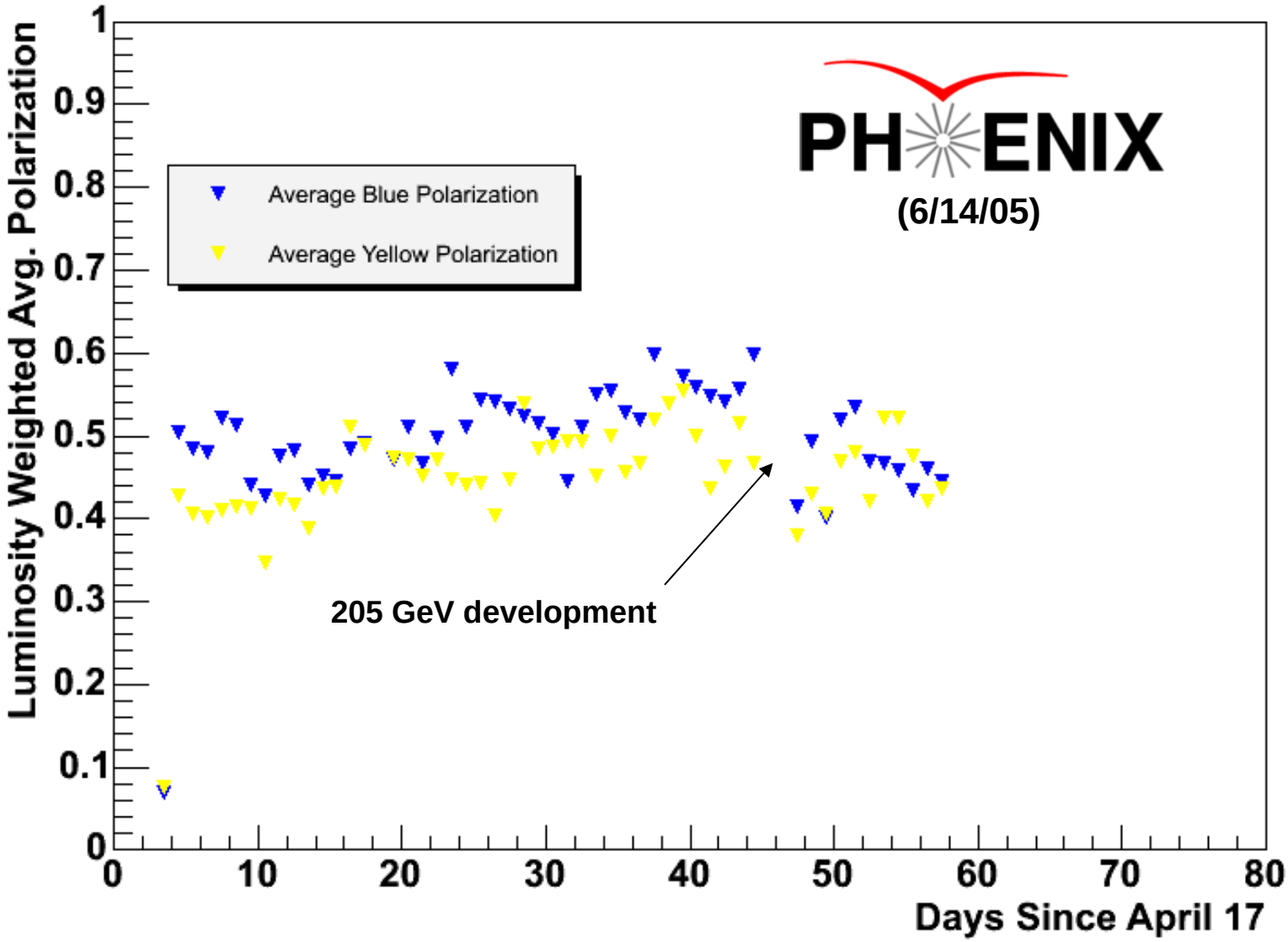
200 GeV pp Integrated Luminosity



200 GeV pp "Figure of Merit"

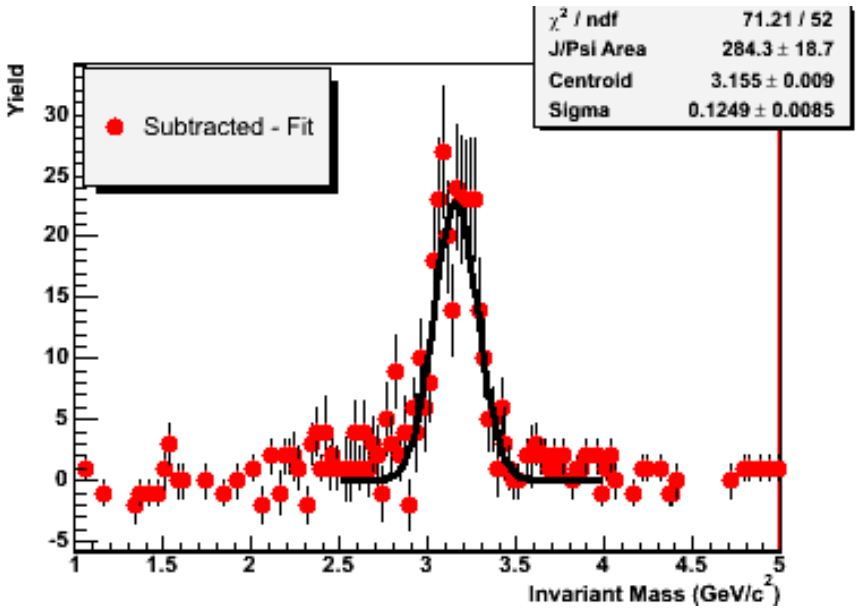


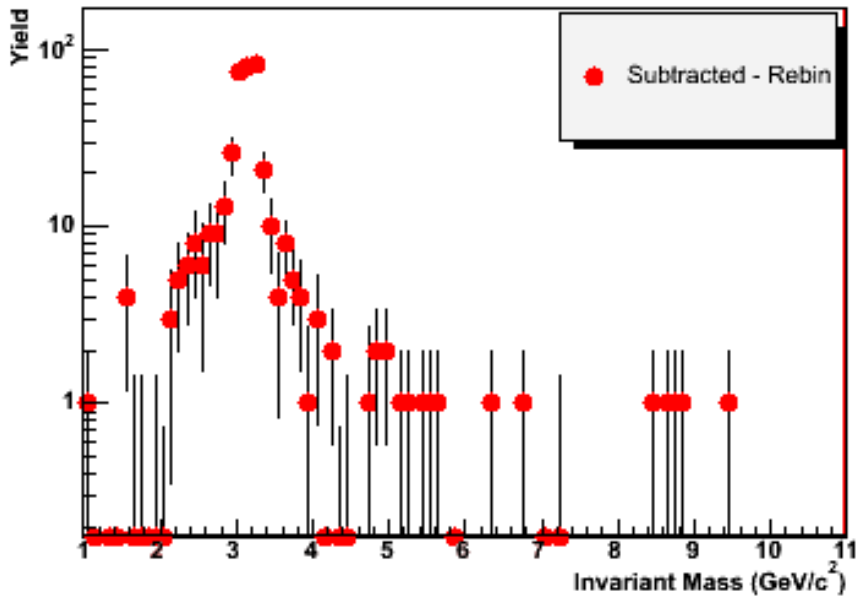
Average Polarization



J/Ψ→e⁺e⁻ in pp 200 GeV

- J/Ψ in central arm data:





284+/-19 J/Ψ

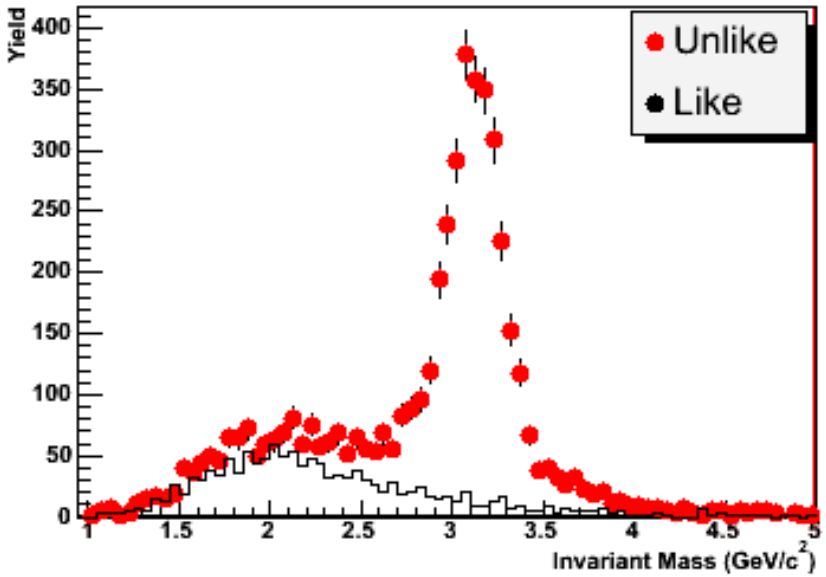
Handful of counts in upsilon mass region

(results from 2.17 pb^{-1} processed through LVL2)

$J/\Psi \rightarrow \mu^+\mu^-$ in pp 200 GeV

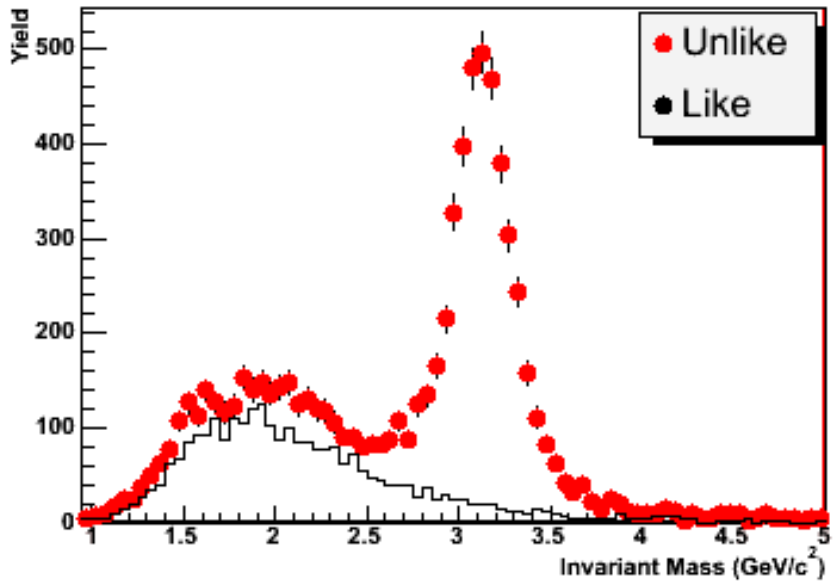
- J/Ψ in LVL2 filtered events:

North Muon Arm



2954+/-59 J/Ψ

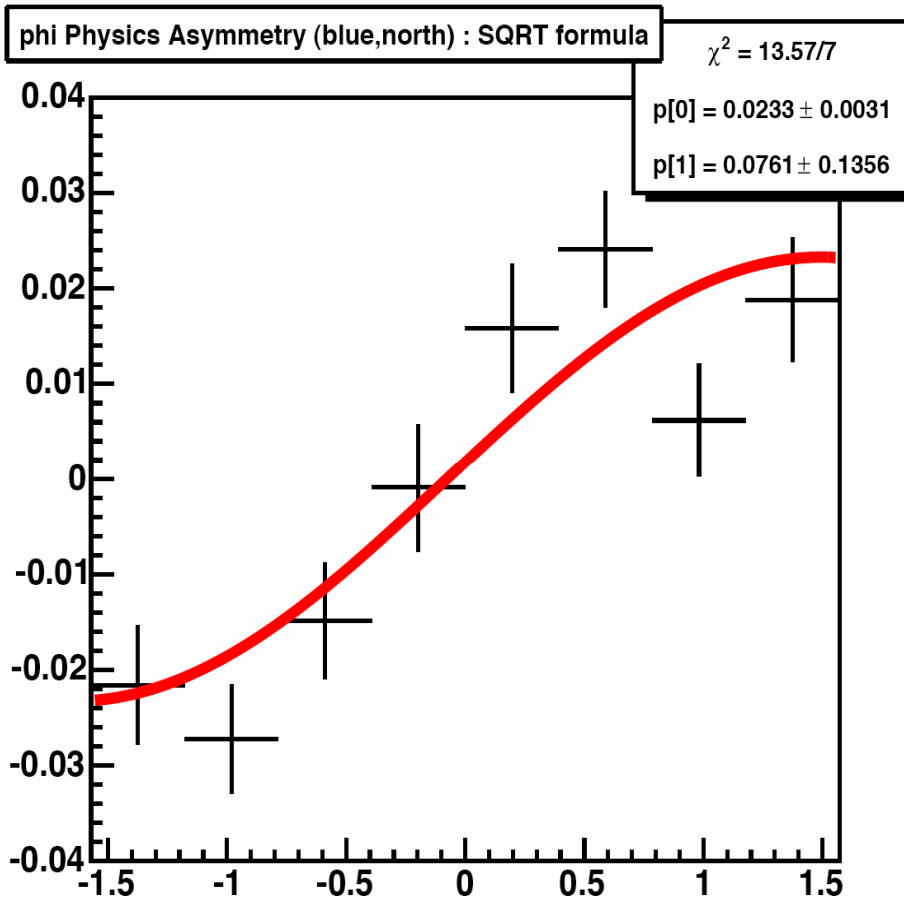
South Muon Arm

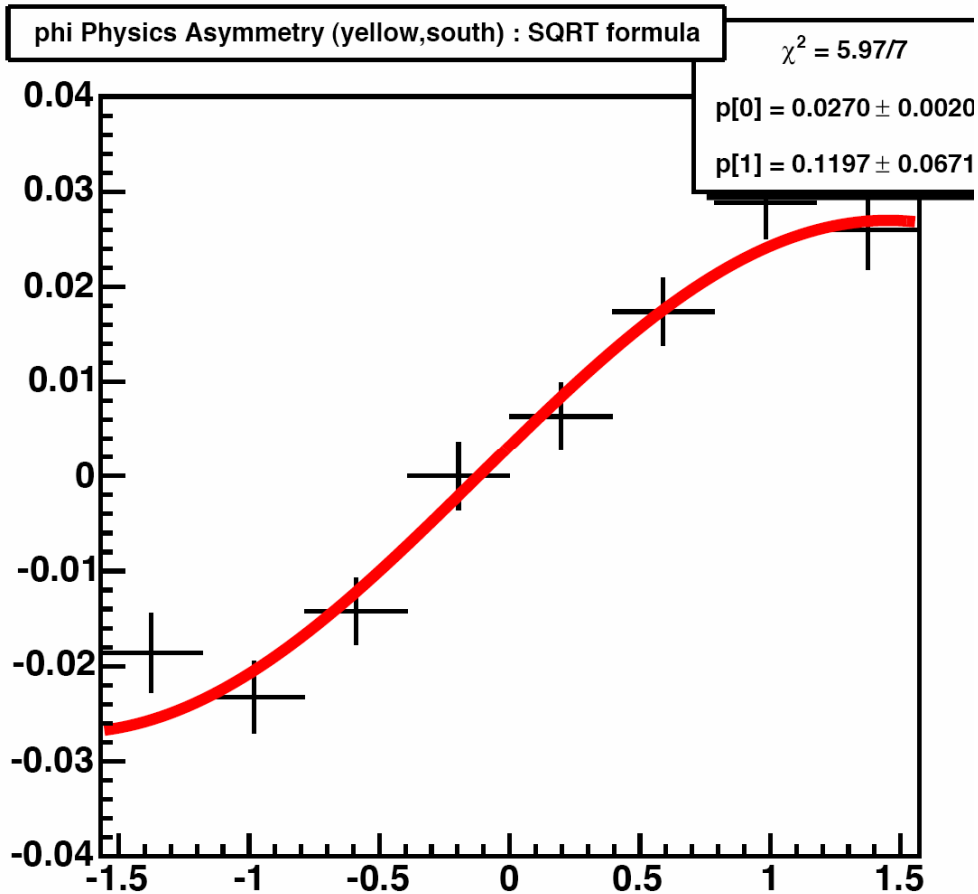


3984+/-70 J/Ψ

(results from 2.17 pb^{-1} processed through LVL2)

Forward Neutron Asymmetry Persists at 410 GeV





Analysis by Manabu Togawa

PHENIX Data Production

- PHENIX is making use of collaboration resources to stay ahead of the incoming data:
  - **Run-4 AuAu Data Production at RCF**
    - Preliminary results from full dataset for QM05
  - **Run-4 Muon Production at CC-F**
    - LVL2 filtered production underway
  - **Run-4 pp Production at CC-J**
  - **Run-5 CuCu 200 GeV/62.4 GeV**
    - LVL2 filtered analysis will yield QM05 preliminary results
    - 100 M minbias events produced in counting house (200 GeV)
    - 150 M minbias events poduced in counting house (62.4 GeV)
    - Full production at RCF this summer (after Run-4 complete)
  - **Run-5 CuCu 22.5 GeV**
    - All events produced in 1008
  - **Run-5 pp production at CC-J**
    - LVL2 filtered analysis
    - Data shipped via network to CC-J at 50MB/s (sustained)

Duty Cycle in Run-5

- Duty cycle defined as "the fraction of the available luminosity sampled by PHENIX"
- CuCu running @200 GeV:
  - Luminosity reported from "lumi" event
    - Poor approximation to "physics" luminosity
    - Ratio of CAD delivered/PHENIX ZDC delivered = **0.35 (200 GeV)**
      - This is **NOT** the PHENIX duty cycle!
      - PHENIX Duty Cycle estimated to be 0.70
        - » "physics" luminosity is only 50% of delivered luminosity
- pp running @200 GeV:
  - Luminosity reported from "soft physics" event
    - Better approximates time available for experiments to take data – *this should be the STAR/PHENIX standard for future running*
    - Ratio of CAD delivered/PHENIX ZDC delivered = **0.75**
      - This **IS** a fair approximation of the PHENIX duty cycle
      - Beam Use Proposal used planning number of 0.6
- More on luminosity reporting later in this talk….
  - For now, concentrate on PHENIX contribution to duty cycle…

The PHENIX Duty Cycle

- What does PHENIX have to do before it can take data?
  - Switch from internal to external clock (at lumi event)
    - Re-initialization of FEM electronics to account for clock "glitch" (made automatic for Run-5)
    - Approximately 2 minutes to complete
    - Systematic elimination of "bad" FEMs during Run-5 resulted in high probability of success
    - Considering changes to PLL circuit already in Master Clock Module
  - Start DAQ
    - DAQ processes can be started once clock switch is complete
    - "Junk" run started with HV low to identify DAQ issues and start troubleshooting
  - Ramp up high voltage
    - Central arms can be ramped up when background counters below 100kHz
    - Muon arm detectors can be ramped up when background counters below 10kHz (arms can be done separately)
      - Ramp rate is determined by detector safety (10-15 min)

What Can Go Wrong?

- A survey of ~ 1 week of problems in the ELOG:
  - 37 HV trips and other HV anomalies
  - 8 gas anomalies
  - MUTR problems
    - 3 GLINK
    - 3 AMU cell/hot channels/bad packets
  - 6 transient false alarms
  - 5 buffer boxes/disks
  - 4 cooling (before the heat wave)
  - 4 TEC bad packets
  - 3 LV/OPC
  - Smattering of single events—DC.W, RHIC server, timing shifts

Common Failure Modes (I)

- HV Trips
  - Can tolerate a few trips in the muon arms
    - MuID trips can be recovered while running
  - Trips in X1/X2 DC layers require stopping run
    - X1/X2 are bend-plane tracking layers
  - Trip recovery can take as long as 10-15 minutes between runs
- FEM readout problems
  - Most systems recovered quickly by an arcnet feed
    - "Quick" feed developed for most systems
    - Feed time takes between 5-10 minutes
    - Failure of module on re-initialization requires subsystem expert intervention
  - MuTR systems very susceptible to readout problems
    - LV power issues
    - Often require an extensive procedure to diagnose and eliminate hung modules.

Common Failure Modes (II)

- Run Control/DAQ issues:
  - No one single failure mode
    - Failed communication between Run Control and various CORBA processes and servers
    - Processes fail to start/stop in event builder
    - Level-1 Trigger problems (configuration and rejection)
    - Data logging problems (buffer boxes)
  - Most common issues addressed through extensive documentation and troubleshooting guide and tools for shift crew
    - Unusual occurrences require DAQ experts
  - Lost time between 5 minutes and 2 hours
    - Large DAQ problems now extremely rare!

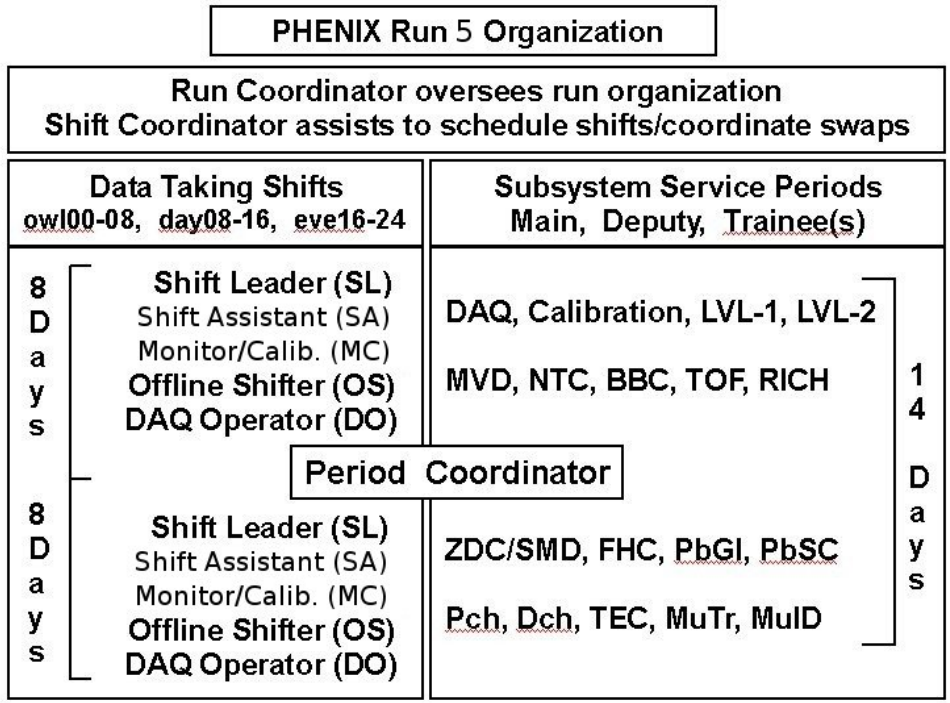
- Conclusions:
  - With the exception of the MuTR readout problems, no single issue dominated the PHENIX duty cycle during Run-5
    - Recabling of MuTR low voltage power supplies a major effort of coming shutdown
  - Substantially lower incidence of DAQ problems in Run-5
    - Emphasis on software reliability, long-term operation has paid off

PHENIX Shift Organization

- PHENIX has a hierarchical shift structure
  - Emphasis on making use of collaboration manpower to run the experiment
  - Relies of teams of "subsystem experts" to maintain and troubleshoot detectors

One of the goals of PHENIX is to train the next generation of nuclear scientists!

Students participate both as shifters and subsystem experts.



Shift Change and Training

- PHENIX maintains a weekly shift schedule:
  - PHENIX shift training on Mondays
  - "Overlap" shifts with previous crew start Tuesday 12AM
  - CAD User's Training also taught on Mondays

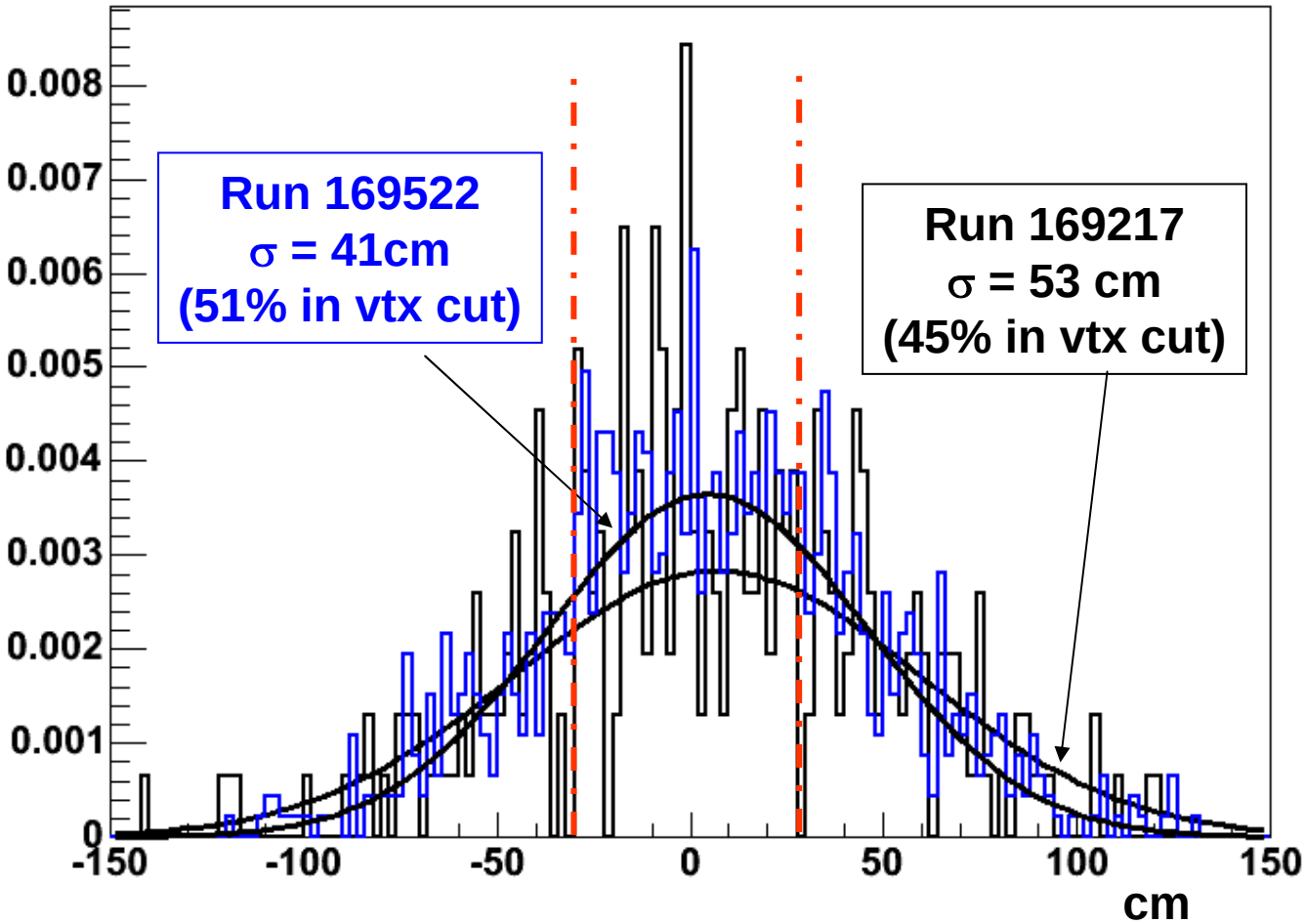
- Overlap shifts are critical to efficient operations!
  - No matter how hard you try, you can't run the experiment by just reading the documentation!
  - Need hands-on experience taking data with the previous shift crew.
  - Need to avoid maintenance and beam experiments on overlap days to optimize experiment operations

- Move overlap days for Run-6?
  - Certainly possible in principle
  - Need to coordinate CAD training with access beam experiments
  - Thursdays instead of Tuesdays?
    - Prefer to have crews "experienced" by the weekend

PHENIX Vertex Distribution

- PHENIX has a limited acceptance in the central arms
  - Events with vertex location > +/- 30cm occur under the central magnet poletips
    - Can take advantage of slightly larger vertex for muon arms in ion runs
- BUP for Run-5 assumed 70% of delivered luminosity within PHENIX vertex cut:
  - For CuCu @200 GeV achieved: 0.63
  - For pp @200 GeV achieved: 0.43
    - No rebucketing
    - Best result achieved ~50% with storage RF ramped up at store (both blue and yellow)
    - Did not achieve effective squeeze on yellow beam throughout run
- PHENIX would like to know what we can expect for Run-6?
  - Any improvements directly translate to more luminosity available for PHENIX

Vertex Cut and Storage RF



PHENIX Vertex Cut: +/- 30 cm (pp)

Increasing Sampled Luminosity

- How do we increase the fraction of the delivered luminosity that is sampled by PHENIX:
  - PHENIX sampled ~1/3 of *physics delivered* luminosity
    - ~1/6 of delivered luminosity
  - Increase the luminosity delivered within the vertex cut
    - Largest single factor for both ions and pp
    - Can storage RF be part of the planning from the beginning?
      - Seems to always be the last development item
    - What can be done with the existing storage RF?
    - Are there RF upgrades that can help?
  - Improve the PHENIX duty cycle
    - No clear answer here, 25% improvement at best
    - Need to continue to monitor throughout the run
  - Improve the speed of collimation and steering at store
    - Big effect for ions (shorter luminosity lifetime)
      - Convert some "delivered" to "physics delivered"

Run Planning

- Translating expected machine performance guidance into experimental goals has been a major issue
  - Failure to communicate assumptions on both sides
  - Failure to understand how physics goals translate into delivered luminosity
  - Failure to appreciate how delivered luminosity goals change when performance parameters vary from assumptions.

- CuCu@200 GeV:
  - PHENIX Beam Use Proposal Assumptions:
    - Geometrical mean of CAD delivered: 7.0 nb^{-1}
      - Assumed to be delivered for physics!
    - PHENIX Duty Cycle: assumed 0.6
    - PHENIX Vertex Cut: assumed 0.7
    - $7nb^{-1}$ x 0.6 x 0.7 = **2.94 nb^{-1} PHENIX Goal**
  - The Realities of Run-5:
    - CAD delivered 15.16 nb^{-1} (!), ~7.58 nb^{-1} for physics
    - PHENIX Duty Cycle: estimated to be 0.7
    - PHENIX Vertex Cut: achieved 0.63
    - $15.9nb^{-1}$ x 0.35 x 0.9 x 0.63 = **3.1 nb^{-1} PHENIX Integrated**

Run Planning (II)

- Polarized pp @ 200 GeV
  - PHENIX Beam Use Proposal Assumptions:
    - Geometrical mean of CAD delivered: 13.1 pb^{-1}
      - Assumed to be delivered for physics!
    - PHENIX Duty Cycle: assumed 0.6
    - PHENIX Vertex Cut: assumed 0.7
    - Average Polarization assumed to be 0.45
    - Integrated Luminosity
      - 13.1nb^{-1} x 0.6 x 0.7 = **5.50 pb^{-1} PHENIX Goal**
    - Figure of Merit
      - 5.50 pb^{-1} x $(0.45)^4$ = **226 nb^{-1} PHENIX Goal**
  - The Realities of Run-5 (up to 6/14/05)
    - CAD *physics delivered* 9.7 pb^{-1}
    - PHENIX Duty Cycle: achieved 0.75
    - PHENIX Vertex Cut: achieved 0.43
    - Average Polarization > 0.5
      - Certainly true prior to 5/30
    - Numbers consistent with current status from slide 10

Future Run Planning

- Request that future planning documents from CAD specify both *delivered* and *physics delivered* luminosity.
  - Makes the conversation between CAD and the experiments much less complicated
  - CAD should convert from delivered to physics delivered, rather than have each experiment do it differently
    - Note that this also sets another performance measure for CAD!
- Experiments should specify clear, measurable performance criteria in beam use proposals
  - For example:
    - Duty Cycle
    - Livetime
    - Vertex Cut (if any)
    - Others?
- This will result in a much simpler set of performance criteria
  - Simplify the process of identifying problems early on!

Operational Issues from Run-5

- Better communication between the CAD RC, Scheduling Physicist, Operations, Polarimetry Group and the Experiments is critical
  - A key problem at the start of proton running (one example):
    - Polarization measurements took 3-4 days to get sorted out
    - Operations unaware of agreements made between experiments and CAD
    - Experiments allowed to place excessive/contradictory demands on operations
  - Role of Scheduling Physicist?

- The transition to physics production running often seems drawn out and inefficient
  - Need to better identify development goals and try to isolate running time from development time.
    - This is very hard to do, especially when things are not going well – but that is when it is critical!
    - Changes should be done in a controlled, systematic manner

- Fixed length stores worked well this run – stick with this!
  - Extend option in BERT a good idea
    - Audio options for BERT also a good consideration

Operational Issues (II)

- Small runs and development issues can have a disproportionately large effect on the physics program
  - Clear priorities must be established and held to!
    - Efficient running benefits from "production" operations
    - High luminosity programs need this!
  - The 410 GeV running is a shining example of how this can work

- Previously known, intentionally unresolved experimental issues cannot be allowed to limit the entire program
  - RHIC cannot continue to develop a high luminosity program if this is allowed to continue
    - PHOBOS vacuum breakdown in CuCu running (neg coated pipe)
    - STAR background issues in pp running (shielding) potential limitation for Run-6
    - Vacuum at 12 o'clock potential limitation for Run-6
  - Known luminosity limitations should be given a high profile at this retreat
    - And that high profile should generate momentum to fix them!

The Future

- PHENIX Upgrades
  - Run-6 potential for a variety of upgrades:
    - Hadron Blind Detector
      - Low mass vector mesons
    - TOF-W Time of Flight Detector
      - Extended PID coverage
    - Installation and availability depend on Run-6 schedule
      - A run starting in January would give us the best chance
- PHENIX ability to handle enhanced luminosity
  - Expect continued development of DAQ bandwidth
    - Design goal is 8-12kHz.
  - PHENIX LVL1 triggers adequate to handle full HI luminosity (even with x2 increase)
  - LVL1 triggers can evolve to accommodate increased luminosity in pp
    - Increased thresholds for photon triggers
    - Di-electron trigger possible
  - Trigger upgrades planned for 500 GeV running

Summary

- Recommendations from PHENIX:
  - Improved communication between experiments and CAD through:
    - Reporting *physics delivered* luminosity
      - Experiments should use this in beam use proposals
    - Experiments track clear performance criteria through the run
      - All experiments report agreed upon set of criteria
    - Improved communications with Operations
      - Scheduling physicist as liason?
  - Identify ways to increase the luminosity delivered to PHENIX within +/- 30 cm
    - What can be done with the existing storage RF?
    - Are there upgrade options that should be considered?
  - Identify potential limitations to luminosity growth
    - Continue to address machine limitations
    - Experiments held accountable for lack of action

Thanks!

- PHENIX appreciates all the hard work from CAD throughout Run-5!
  - There is no way to look at this run as anything less than a major success!